

# RECENT TRENDS IN THE WHITE STURGEON POPULATION IN CALIFORNIA'S SACRAMENTO- SAN JOAQUIN ESTUARY<sup>1</sup>

DAVID W. KOHLHORST  
California Department of Fish and Game  
Bay-Delta Fishery Project  
4001 North Wilson Way  
Stockton, CA 95205

Recent trends in the white sturgeon, *Acipenser transmontanus*, population in the Sacramento-San Joaquin Estuary were evaluated from commercial passenger fishing boat (CPFB) and tagging records. Total catch and catch/angler h on CPFB's declined from 1967 to 1974. Catch/angler h increased from 1974 to 1978, while total catch continued to decrease through 1977. Population estimates suggested that a decrease in abundance occurred between 1967 and 1974 and that abundance increased between 1974 and 1979. Mean size of sturgeon caught on CPFB's increased from 1964 to 1973 or 1974, then decreased through 1978. Annual survival rate changed little over the period examined. The population decline was likely due to poor recruitment from year classes produced after the mid-1950's. Possible causes of low recruitment are discussed.

## INTRODUCTION

This report analyzes trends in the white sturgeon, *Acipenser transmontanus*, population in the Sacramento-San Joaquin Estuary from 1964 to 1979. This species is a native anadromous fish in the Sacramento-San Joaquin Estuary and is the object of a small but important sport fishery. Another species, the green sturgeon, *A. medirostris*, is much less common and legal-sized ( $\geq 101.6$  cm total length) fish are seldom caught.

Sturgeon are long-lived, late-maturing fish (Roussow 1957; California Department of Fish and Game, unpublished), some living over 50 yr and most maturing at 10 to 15 yr. Fishes with this type of life history normally exhibit long-term population stability and a slow response to environmental vicissitudes (Goodman 1975). Hence, sturgeon populations are vulnerable to overharvest and subsequent decline (Bajkov 1949; Dees 1961) because they cannot rapidly compensate for unusually high mortality.

Historical accounts indicate that a commercial fishery substantially reduced the Sacramento-San Joaquin Estuary white sturgeon population in the late 1800's (Skinner 1962). After a complete fishing closure in 1917, the sport fishery was reopened in 1954. Through 1963 the only catches were generally incidental to the striped bass, *Morone saxatilis*, fishery. Fishing success improved dramatically in 1964 when shrimps, *Crangon* spp. and *Palaemon macrodactylus*, first became popular as bait. Estimated annual harvest rates have been low: at least 2% in 1954 (Chadwick 1959), 7.3% in 1967, 6.5% in 1968 (Miller 1972), and 5.6% in 1974 (Kohlhorst 1979).

Changes in abundance, catch, mean size, and survival may provide clues to factors affecting the sturgeon resource and influence management of the fishery. Over-exploitation is normally characterized by decreasing catch/unit effort and

declining mean size of fish in the catch (Gulland 1971). Reduced recruitment also causes decreasing catch per unit effort, but mean size increases. The former would suggest that harvest should be restricted, while the latter requires investigation of the causes of poor recruitment. Stable or increasing abundance measurements would suggest a healthy population.

## METHODS

White sturgeon population trends were interpreted from catch, effort, and size data reported by commercial passenger fishing boat (CPFB) operators and from catch/effort, size, and absolute abundance estimated from tagging studies. Since variations in annual survival might have caused fluctuations in abundance, I evaluated survival rates from the only data available. These data provided estimates of survival in 1967 from tag returns and average annual survival over several years from a catch curve.

The CPFB reports were compiled annually from 1964 to 1978 for trips when sturgeon were caught to determine trends in total catch and catch/angler h. Operators of CPFB's are required to furnish the Department with daily logs listing species, number, and sizes of fishes caught, number of anglers, and time spent fishing.

Catch/net h during tagging in San Pablo Bay was available for fall 1967, 1968, 1974, and 1979. This catch/effort index was based on trammel netting in similar areas and months in all 4 yr.

Trends in size of sturgeon were determined from: (i) annual mean lengths and weights calculated from information on logs submitted by the CPFB operators (operators chose to report either length or weight; they seldom reported both), and (ii) mean lengths of white sturgeon tagged in 1967, 1968, 1974, and 1979.

Mark-recapture estimates of legal-size white sturgeon abundance were available from tagging studies in 1954 (Pycha 1956) and 1967 (Miller 1972). Pycha's estimate was derived from a multiple census technique and Miller's was a Petersen estimate. For comparison, I estimated abundance from tagging studies in San Pablo Bay in 1967, 1968, 1974, and 1979 (Miller 1972; Kohlhorst 1979) using the multiple census technique of Shumacher and Eschmeyer (Ricker 1975), where:

$$N = \frac{\sum (C_t M_t^2)}{\sum (M_t R_t)}$$

and: N = estimated population

M<sub>t</sub> = total tagged fish at large at the start of the t<sup>th</sup> day

C<sub>t</sub> = total fish caught on day t

R<sub>t</sub> = number of recaptures in the sample C<sub>t</sub>.

All the multiple census abundance estimates likely are biased downward as tagged fish probably did not mix randomly with the untagged population during the 2-month tagging season. Sturgeon not in San Pablo Bay were neither subject to tagging nor recapture. Hence, overall, tagged fish would have been more vulnerable to recapture than untagged fish to initial capture. This differential vulnerability, plus effects of immigration to and emigration from San Pablo Bay, make determining the proportion of the entire sturgeon population represented

ates probably reflect major trends. However, due to their imprecision, my intent is to present them as supplementary to the other data.

I estimated average annual survival rate from a catch curve (Ricker 1975) using age frequencies of sturgeon collected mostly during tagging in 1974 and on CPFB's in 1973–1976. Aging was as described by Kohlhorst, Miller, and Orsi (1980). The slope of the descending right limb of the curve was estimated using least squares fit of the linear regression equation:  $\log_{10}(\text{number of fish}) = a - b(\text{age})$ . The antilog<sub>10</sub> of the slope ( $b$ ) is an estimate of survival.

Miller (1972) estimated first year survival of sturgeon using 2 yr of returns from tagging in 1967 and 1968. I re-estimated this survival rate and its confidence interval with 6 yr of returns using a bias-adjusted maximum likelihood equation Model 1 of Brownie et al. (1978):

$$S_1 = \frac{R_1(T_1 - C_1)(N_2 + 1)}{N_1 T_1 (R_2 + 1)}$$

where:  $S_1$  = survival rate in 1<sup>st</sup> yr after 1967 tagging

$R_1$  = total returns from 1967 tagging

$R_2$  = total returns from 1968 tagging

$T_1$  =  $R_1$

$C_1$  = returns in 1<sup>st</sup> recovery year

$N_1$  = number of fish tagged in 1<sup>st</sup> yr

$N_2$  = number of fish tagged in 2<sup>nd</sup> yr

Confidence limits for  $S_1$  were calculated as  $S_1 \pm 1.96SE(S_1)$ , where:

$$SE(S_1) = \sqrt{S_1^2 \left( \frac{1}{R_1} - \frac{1}{N_1} + \frac{1}{R_2} - \frac{1}{N_2} + \frac{1}{T_2 - R_2} - \frac{1}{T_1} \right)}$$

and  $T_2 = R_2 + T_1 - C_1$ . The other elements are the same as above.

## RESULTS

### Catch Data

Fishing success declined during much of the period examined. Sturgeon catch reported by CPFB's declined from a peak of 2,272 fish in 1967 to a low of 327 fish in 1977 (Figure 1). Catch/angler h on CPFB's decreased from 0.052 in 1964 to 0.028 in 1974 and then increased to 0.039 in 1978 (Figure 1). Negative linear trend lines for both catch (1967–1978) and catch/angler h (1964–1974) were significantly different from zero ( $p < 0.0005$ ). The positive trend in catch/angler h from 1974 to 1978 was not significantly different from zero ( $p \approx 0.10$ ).

Legal-sized white sturgeon also were more difficult to catch with trammel nets in San Pablo Bay in 1974 than in 1967, 1968, or 1979. Catch/net h during tagging was 15.3 in 1967, 19.5 in 1968, 3.7 in 1974, and 8.4 in 1979. Hence, catch rate in 1974 was 79% lower than the 1967–1968 mean and 56% lower than in 1979.

Mean length of sturgeon reported by CPFB's increased from 124 cm in 1964 to 134 cm in 1974 (Figure 2). Sample sizes were too small from 1975 to 1978 (only 1 to 11 fish) to calculate reliable mean lengths. Mean weight increased

( $p < 0.0005$ ). The negative trend in mean weight from 1973 to 1978 was also statistically significant ( $p < 0.0005$ ).

The mean length of sturgeon captured for tagging also increased from the late 1960's to 1974, then declined substantially between 1974 and 1979 (Figure 2).

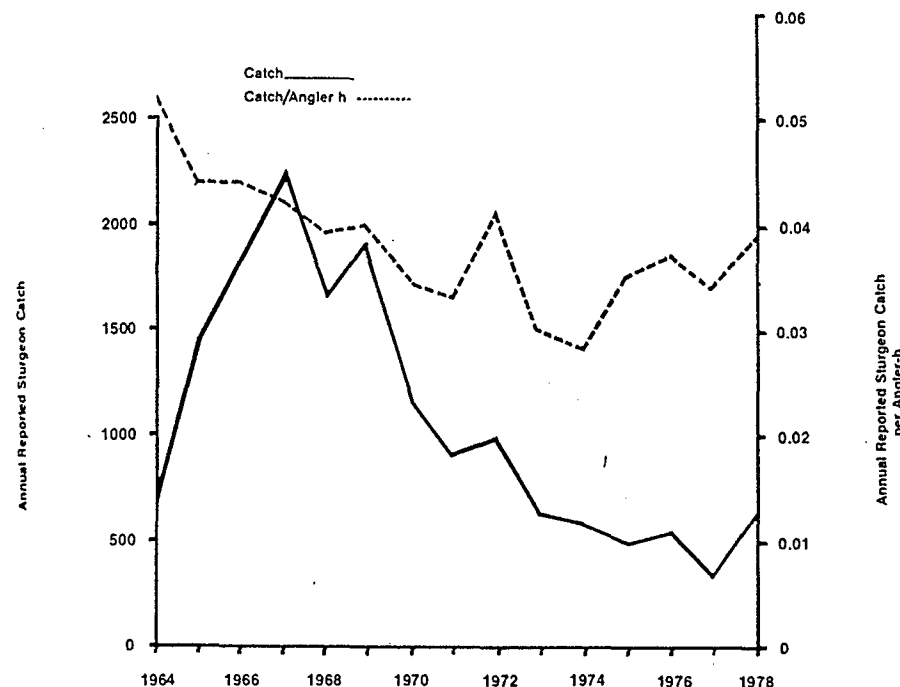


FIGURE 1. Annual reported sturgeon catch and catch/angler h by commercial passenger fishing boats in the Sacramento-San Joaquin Estuary.

### Mark-Recapture Estimates

From 1967 to 1974, trends in the mark-recapture abundance estimates (Table 1) were about the same as those demonstrated by the CPFB and netting data. Specifically, the estimate for 1974 was lower than those for 1967 and 1968 and the estimate for 1979 suggested abundance increased after 1974. My 1967 estimate was similar to Miller's (1972) for the same year, but a major inconsistency is that the estimate for 1968 is lower relative to 1967 and 1979 than would be expected from the other data. Presumably, this reflects the previously mentioned imprecision in the multiple census data. The 1954 estimate is lower than any of the more recent estimates suggesting abundance was relatively low then.

### Survival Estimates

The slope of the righthand limb (age 9–20) of the catch curve for white sturgeon collected in 1973–1976 was  $-0.0569$  (Figure 3). Estimated mean annual survival (antilog<sub>10</sub>  $-0.0569$ ) was 0.878 (95% CI = 0.818, 0.941). The scatter and moderate nonlinearity of points in the righthand limb suggest that survival

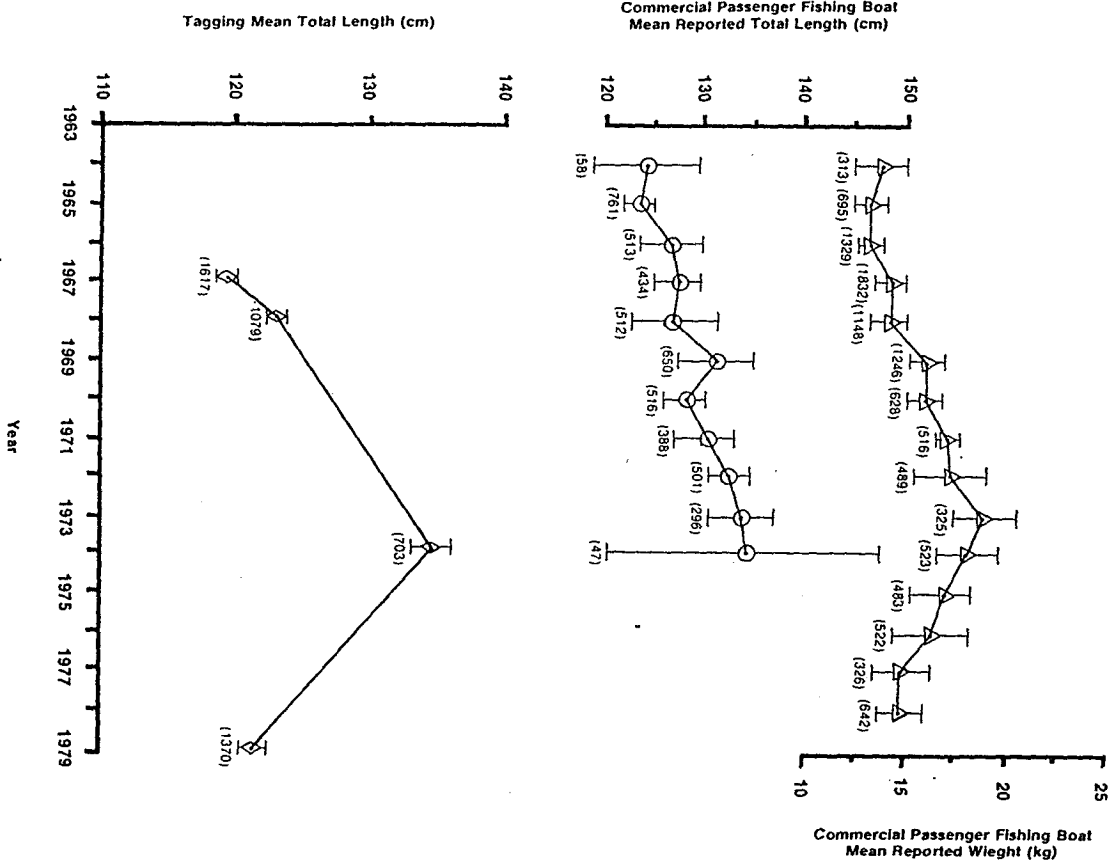
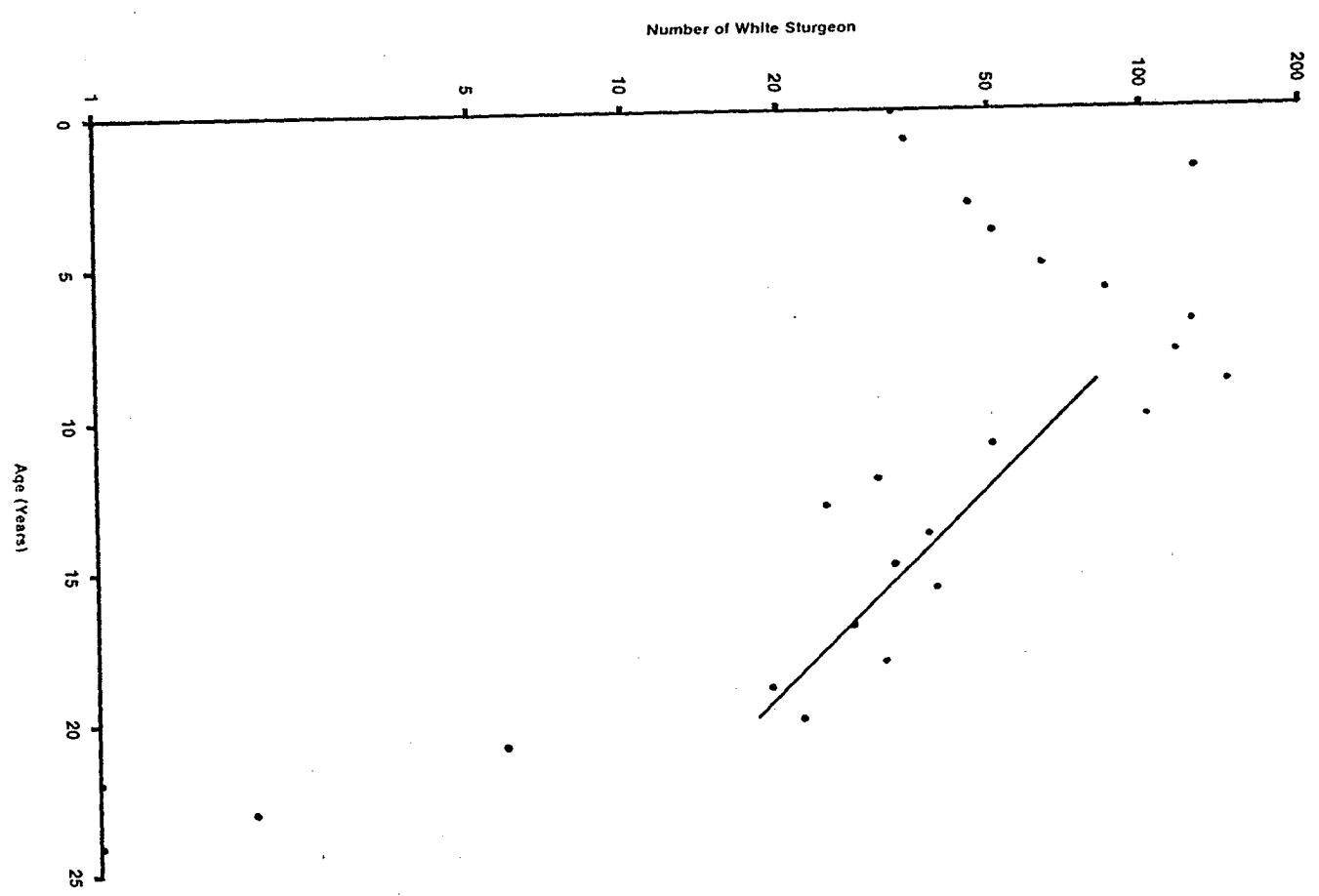


FIGURE 2. Annual mean weight and total length reported by commercial passenger fishing boats and mean total length during tagging of sturgeon in the Sacramento-San Joaquin Estuary. Bars are 95% confidence intervals and numbers in parentheses are sample sizes.

Six years of returns from tagging in 1967-1968 (Table 2) yielded an estimated survival rate of 0.841 (95% CI = 0.648, 1.03) for the first year after tagging in 67. The similarity of these two estimates suggests that changes in survival rate are not large enough to cause the observed fluctuations in abundance.



However, all females from a year class do not mature at the same time and many live long enough to spawn more than once. These older fish have higher fecundity than first-time spawners. These facts suggest the explanation is more complicated than a simple 14-yr cycle.

Exploration of factors possibly affecting sturgeon recruitment is continuing. If recruitment is affected by controllable factors, these could be manipulated to increase sturgeon abundance.

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